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AN EXPERIMENTAL INVESTIGATION OF MATERIAL REMOVAL RATE AND SURFACE ROUGHNESS ON NAVAL BRASS (C360) BY CONSIDERING DIFFERENT PARAMETERS ON CNC TURNING

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ABSTRACT
In present scenario CNC turning operation plays a vital role in metal based manufacturing industries. Therefore selection of optimum machining parameters, Tool geometry and cutting condition etc. for the variety of materials is an important and complicated task for the manufacturing industries in providing best quality at less cost to the customers. In this research work CNC turning operation is carried out using L_9 Taguchi orthogonal arrays on Naval brass C360 coated carbide insert and influence of CNC turning process parameters like Cutting Speed, Feed and Depth of Cut are analysed for two output objectives like material removal rate and surface roughness. The optimum sets of turning process parameter as well as combined effect of considered response are estimated using Taguchi technique application. In this analysis it is found that depth of cut has the largest effect on metal removal rate and feed rate has the largest effect on the surface roughness.It can be observed that depth of cut has the largest effect on metal removal rate and feed rate has the largest effect on the surface roughness of C360 brass by turning on CNC. The optimum turning condition for material removal rate isspindle speed (1600 rpm), feed rate (0.20 mm/rev.) and depth of cut (0.8 mm). The optimum condition for surface roughness is spindle speed (1400 rpm), feed rate (0.20 mm/rev.) and depth of cut (0.2mm).

KEYWORDS: CNC parameters optimization, carbide tool, naval brass C360, Taguchi method.

I. INTRODUCTION
Machining is most widely used process in the manufacturing industries. So it is challenging to acquire good surface finish and less tool wear while working with materials having high strength, high toughness, corrosive resistance, and brittleness and wear resistance in turning [1]. In order to overcome the above problem, optimized cutting parameters are to be employed so optimization is very much essential in industrial application [2]. Taguchi method is introduced which is an important statistical tool that provides cost effective and systematic way to optimize cutting parameters.[3]It has been successfully used in designing good quality at low cost in the field of automotive, aerospace etc. [4].

Turning is a machining process to produce parts round in shape by a single point tool on lathes [5]. The tool is fed either linearly in the direction parallel or perpendicular to the axis of rotation of the work-piece, or along a specified path to produce complex rotational shapes [6]. The primary motion of cutting in turning is the rotation of the workpiece, and the secondary motion of cutting is the feed motion [7].Machining is simply metal removal from the raw material to create well finished products. It involves the shaping of a part through removal of material [8].

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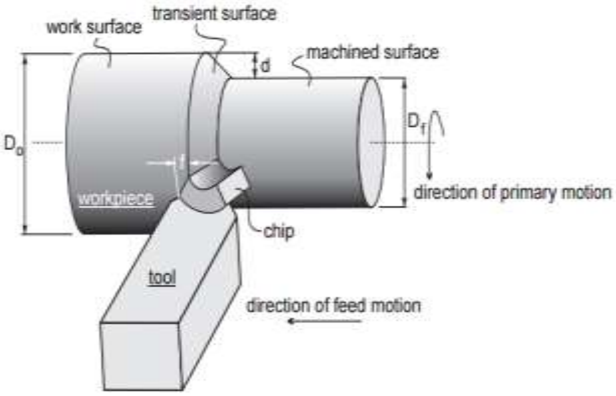

Where:
f = feed
d = Depth of Cut
D_o = Initial Diameter
D_f = Final Diameter

Fig. 1: Turning Operation [13]

Nomenclature

SS: Spindle Speed
DOC: Depth of Cut
SR: Surface Roughness
MRR: Material Removal Rate
SNR Signal-To-Noise Ratio

II. DESIGN OF EXPERIMENTAL SET UP AND PROCEDURE

The selection of work piece material, machine tool, process and performance parameters and procedure opted to carry out the optimization is presented below.

Work Piece material

Naval brass C360 is chosen as work piece material.It is the classic marine, high-strength and corrosion-resistant alloy containing copper, zinc and tin.It is widely used in marine construction where strong, corrosive-resistant and hard material is required and is suitable for both salt and fresh water applications.The chemical composition and physical properties of selected C360 as shown in table 1& 2

Table 1.Chemical Composition of C360

Elements	Weight Percentage
Copper (Cu)	60 - 63%
Lead (Pb)	2.5 - 3.7%
Iron (Fe)	0.30 - 0.35%
Zinc (Zn)	37 - 40%

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Table 2.Mechanical Properties of C360

Property	Range
Yield Stress	315 – 537 N/mm^2
Elongation	0.2 – 0.27% in inch
Hardness	Rockwell B Scale 72 – 78
Density	8.2 – 8.7 g/mm^3

Cutting tool material

The cutting tool TNMG 2020 TTS is used for conducting the turning operation on C360 Fig. 2.

Fig.2:Cutting tool TNMG 2020 coated inserts used for turning operation

Table 3: Details of cutting tool used for turning experiments

Insert shape	Condition of Machining	Cutting tool specification	Tool Material	Rake angle	Clearance angle	Nose radius	Cutting edge angle
Rhombic	Turning	TNMG 2020	Coated tungsten carbide	0^0	7^0	0.8mm	80^0

Machine tool

JyotiSTC 200 CNC model was used for this experiment work as shown in figure 3. The detailed specification of this machine is shown in table 4.

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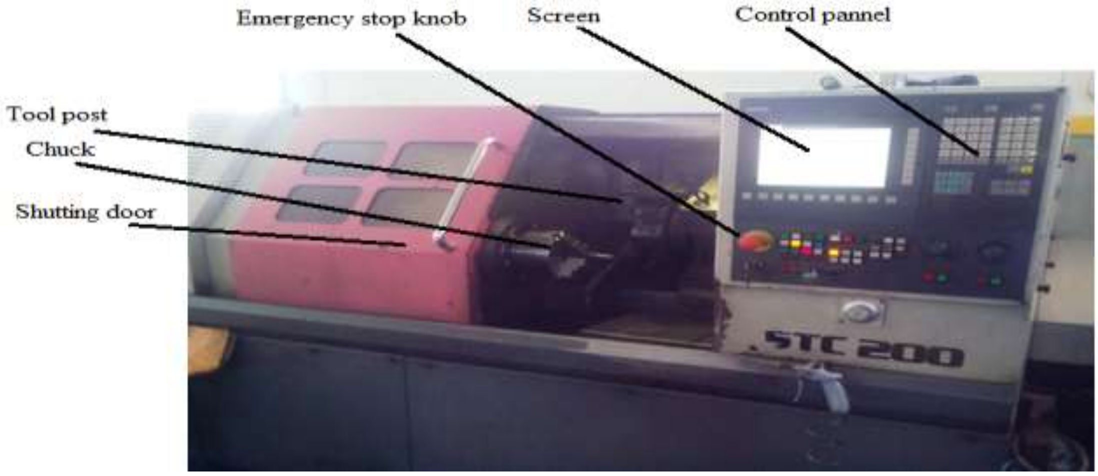

Fig. 3 STC 200 CNC lathe for experimentation

Table 4: Specification of CNC lathe

Specification	Description
Maximum bar diameter	190 mm
Maximum turning length	380 mm
Maximum speed	4000 rpm
Power main spindle	6.2 kw
Number of tool positions turret	8

Figure 4 explains the turning operation being carried out on CNC lathe machine. Specimen is held in three jaw chuck and TNMG 2020 Tool insert is used for the turning operation.

Fig. 4.4:Turning of C360 on CNC lathe

Response parameters measurement apparatus

In this experimental study, two measuring apparatus are employed viz. a digital surface tester and digitalweighing machine. After turning operation one response parameter that is surface roughness is measured with the help ofTalysurfMitutoyo SJ-210.Electronic weighing machine with maximum capacity of 30000 gm and least count 0.001 gm. is used to estimate material removal rate as shown in figure 4.

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Fig. 4 Surface roughness testing and weighing for MRR

Selection of turning parameters and their levels

In the turning operation three parameters like spindle speed (rpm), feed (mm/rev) and depth of cut (mm) play animportant role to get desired quality level output. Therefore these turning parameters and their associated levels are selected based on preliminary literature review and catalogue provided by cutting tool manufacturer for machining of C360 brass. The levels of turning process parameters are shown in table 5.

Table 5: Selected Parameters and their levels for experimentations

Parameters / Levels	Spindle Speed (SS) (rpm)	Feed Rate (FR) (mm/rev)	Depth of Cut (DOC) (mm)
1	1400	0.08	0.2
2	1600	0.14	0.5
3	1800	0.20	0.8

Machining performance selection

In present experimental study two important responses like Surface roughness and Material removal rate are selected for finding out the optimum turning process parameters. Surface roughness response is measured usingTalysurfMitutoyo SJ-210 in micron and material removal rate is calculated by the weight difference of the work piece before and after machining using weighing machine and the measured machining time in mm3/min.

III. OPTIMIZATION METHODOLOGY (TAGUCHI METHOD)

To evaluate the machining performance Taguchi introduced three types of quality characteristics viz. smaller isbetter, nominal is the better and higher is the better. To obtained proposed machining performance in term of signalto noise ratio (SNR) following two equations are used:

1. **Signal-to-Noise Ratio for Material Removal Rate (MRR)**

$$\left[\frac{S}{N} = -10\log\left(\frac{\left(\Sigma\frac{1}{Y_i^2}\right)}{n}\right) \atop Larger - The - Better\right]$$

2. **Signal-to-Noise Ratio for Surface Roughness (SR)**

$$\left[\frac{S}{N} = -10\log\left(\frac{(\Sigma Y_i^2)}{n}\right) \atop Smaller - The - Better\right]$$

IV. RESULT ANALYSES AND DISCUSSION

Table 5 shows the full factorial design of experiment with independent parameter, their levels and measured SNRvalue of response variables using mentioned Taguchi quality characteristics method for surface roughness and material removal rate.

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Table 6: L_9 Orthogonal arrayfor Material removal rate and Surface roughness

Exp. No.	SS	FR	DOC	MRR	S/N Ratio for MRR	SR	S/N Ratio for SR
1	1400	0.08	0.2	2.270	7.1205	1.785	-5.038
2	1400	0.14	0.5	3.374	10.5629	2.136	-6.592
3	1400	0.20	0.8	5.600	14.9638	4.260	-12.588
4	1600	0.08	0.5	4.859	13.7309	1.190	-1.510
5	1600	0.14	0.8	5.955	15.4976	2.830	-9.035
6	1600	0.20	0.2	2.730	8.7233	4.060	-12.170
7	1800	0.08	0.8	5.233	14.3750	1.260	-2.007
8	1800	0.14	0.2	2.382	7.5388	2.330	-7.347
9	1800	0.20	0.5	5.469	14.7582	4.985	-13.953

Table 7: The response of independent parameters for material removal rate (larger is better)and surface roughness (Lower is better) of C360

Material removal rate				Surface Roughness			
Level	SS	FR	DOC	Level	SS	FR	DC
1	10.882	11.742	7.794	**1**	-8.071	-2.850	-8.183
2	12.651	11.200	13.017	**2**	-7.572	-7.658	-7.352
3	12.224	12.815	14.945	**3**	-7.769	- 12.904	-7.877
Delta	1.768	1.615	7.151	Delta	0.499	10.054	0.831
Rank	**2**	**3**	**1**	Rank	**3**	**1**	**2**

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Main effect plot for S/N ratio of MRR

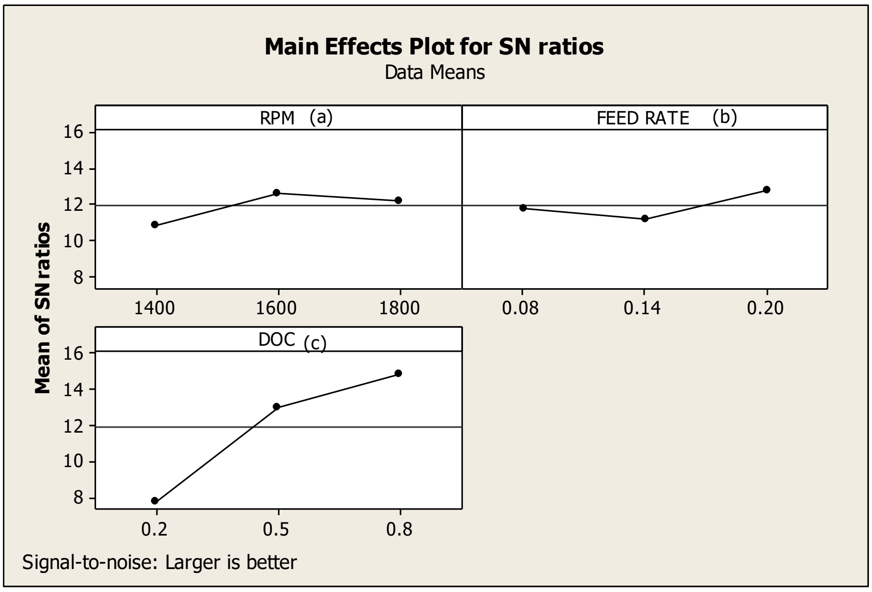

Fig.5:Represents the effect of operating parameters on S/N ratio of MRR.

From the graph it is clear that the optimal cutting parameters are medium of spindle speed, maximum of feed rate, and also maximum of depth of cut to obtain good quantity of metal removal rate (MRR) and which is also indicated in table 6. From the result, the interaction of spindle speed and depth of cut is more important than the effect of the individual factors.

Main effect plot for S/N ratio of SR

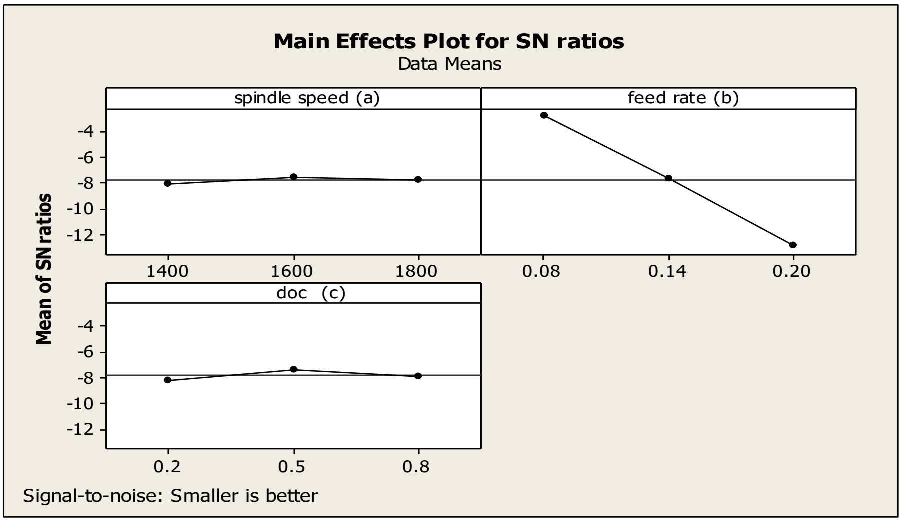

Fig.6:Described the effect of operating parameters on S/N ratio of surface roughness

From the graph it is clear that the optimal cutting parameters are minimum of spindle speed, maximum of feed rate, and also minimum of depth of cut to obtain bettersurface roughness (smaller is better) and which is also indicated in table 6. This is due to the increased friction between work piece and tool interface, which eventually increases the temperature in the cutting zone.Hence the shear strength of the material reduces and the material behaves in a ductile fashion as discussed by Munish Kumar Gupta and P.K. Sood in 2016. Moreover the material is sticky in nature which makes the chips to detach from the work piece with utmost difficulty, thereby increasing the surface roughness. There was decline in surface roughness with increase in spindle speed from minimum to medium i.e. from 1400 rpm to 1600 rpm. However, further increase in spindle speed causes an increase in surface roughness. It can also be observed that the minimum Ra of machined surfaces is obtained when cutting sp

V. CONCLUSIONS

1. It is concluded that for C360 optimum machining condition for Material Removal Rate (MRR) with Spindle speed (1600 rpm), feed rate (0.20 mm/rev) and depth of cut (0.8 mm).
2. It is determined that for C360 optimum machining condition for Surface Roughness (SR) with Spindle speed (1400 rpm), feed rate (0.08 mm/rev) and depth of cut (0.2 mm).
3. MRR increased with the increased in the process parameters while SR is decreased with the increase in process parameters.This is due to the increased friction between work piece and tool interface.
4. It is noted that depth of cut has the largest effect on metal removal rate of C360 by turning on CNC lathe.
5. It can be observed that feed rate has the largest effect on the surface roughness of C360 by turning on CNC lathe.

VI. FUTURE SCOPE

Though a systematic experimental study has been carried for the machining ofC360 using CNC lathe, ample scope is there for carrying out further research in the area.

- In this present work MRR and SR of machined product were studied during the machining ofusing CNC lathe can futher be carried out to study the machining characterstic known as tool wear rate etc.
- By using different material i.e. Hot die steel, Al/SiC/Gr, or any hybrid composite machining characteristics can be further studied..
- By varying Tool material, Coolant type, Coolant Flow and other CNC parameters can be further studied..

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